MESSAGE

5 Technology Is a Tool

CHANGING MATHEMATICS IN A TECHNOLOGICAL WORLD

Computers and calculators were invented to save humans time and to allow us to solve more challenging problems more easily than we could otherwise. The pace of technological advances today is staggering. Potential applications for technology are increasing exponentially and the cost and availability make some forms of technology accessible to nearly everyone. Calculators, computers, and a growing array of technological innovations have become important tools for doing mathematics, joining the ranks of the compass, straightedge, pencil, and (in earlier days) the slide rule and trig tables. Yet it's been noted that some school mathematics curricula seem like efforts to make technology obsolete—they essentially pretend that technology does not exist.

Today's technology is not a panacea for transforming the teaching and learning of mathematics, but neither is it the source of all the difficulties in mathematics classrooms. Instead of discussing whether particular forms of technology are good or bad, we need to discuss how we can capitalize on these tools to help every student learn more mathematics, not less.

The Influence of Technology on Curriculum

Technology is here to stay, and it generates at least three important effects on the school mathematics curriculum. First, some mathematics is now *more important* than in the past because it plays a role in the design and use of technology. For instance, discrete mathematics topics such as matrices take on new significance in light of their use to organize information in the rows and columns that form the basis for spreadsheets. Matrices are now routinely used as technological tools to help us solve many problems in fields such as manufacturing, travel, and marketing. Furthermore, the ability for technological tools to deal with mathematical data in many forms means that students now need to be more proficient than in the past in translating from one form to another, moving among numbers, symbols,

graphs, and tables, as they choose which representation can help them solve a particular problem. Even the basic task of changing fractions to decimals and vice-versa takes on new importance as students interact with calculators or software that may deal more directly with decimals than with fractions. All of these topics and skills are more important in this technological age than in the past.

At the same time, technology makes some mathematics *less important*. This idea is controversial—some fear computation will disappear from the school curriculum since calculators can perform certain types of basic operations quickly and accurately. However, even in an age of technology, it remains important for students to know how to add, subtract, multiply, and divide mentally and with a pencil and paper. But we must determine how much valuable instructional time we should devote to helping students become proficient with lengthy or tedious calculations. Determining how long a divisor is long enough in the study of long division, for example, is now an important educational decision. While some proficiency with multidigit procedures is preferred in most communities, the relative priority of this type of work is worthy of discussion. In the typically crowded American mathematics curriculum, often described as a mile wide and an inch deep, deciding what to omit is crucial, especially as emerging topics vie for inclusion.

The third and most important way in which technology affects the mathematics curriculum is that it makes some mathematics *possible* for the first time. Using calculators, students at all levels can tackle real problems that might arise from planning a field trip or from interpreting a recent news story, for example, even if the numbers involved might make the problem unwieldy with only a pencil and paper. Middle school students can analyze data using a wide range of statistical tools, thus developing quantitative reasoning abilities far beyond what was once possible. Graphing calculators allow students to see the connections between visual and symbolic representations of mathematical situations. These multifaceted calculators can be a useful tool for modeling a variety of problem situations. We are just beginning to scratch the surface of the potential of computerized algebra systems and other emerging forms of technology. These are but a few examples of how technology can help all students tackle complex problems not otherwise accessible to them, in the process raising their level of mathematical creativity and thinking.

Teaching with Technology

The teacher is a key decision maker in using technology effectively in the classroom. Teachers' most important technology decision is to determine when students should use technological tools and when they should not. Students need to learn when to do something in their heads, when to reach for a pencil, and when to use technology. Technology decisions, just

like other instructional decisions, call for teachers to have a solid knowledge of mathematics and a working knowledge of available technological tools. There is nothing wrong with students knowing more than their teacher about how to use some features of a calculator or a piece of software. But there is something wrong if a teacher prohibits or limits the use of technology because of his or her own discomfort, or if a teacher allows unlimited use of technology without helping students master essential mental tools (including number sense, operation sense, estimation skills, and thinking skills). Teachers need to know how to help students access higher-level mathematics using the tools available, and not relegate the use of tools to only checking answers or repeating procedures students have already done by hand.

Who Gets Access to Technology?

Ensuring that all students have access to technology for both in-school use and for homework is the responsibility of schools and school systems; it should not be left solely to students and their families. Ensuring such access can carry significant budget implications that call for serious ethical discussions among educators. But it is not reasonable to expect all students to buy graphing calculators that may cost more than their shoes or to expect every family to have a home computer with online access. Requiring such a burden of families means that some students will have access to sophisticated tools and others will not. If we allow this burden to become the norm, society will face a digital divide greater and more dangerous than any economic gap we have yet seen in schools. The same can be said if some students have access to computers or other sophisticated technologies outside of school while other students do not. Neither is it acceptable for students in poor communities to be denied the opportunity to access higher-level mathematics because their school cannot afford appropriate tools or does not prioritize the purchase of such tools. Furthermore, it is not acceptable that some schools have access to only outdated hand-me-down technology.

What Can We Do?

Mathematics can no longer be the cheapest subject in the school budget. What was once done with little more than chalk or overhead pens now calls for a significant and ongoing investment in technology. In times of tight budgets, this can be a real challenge. But if we are serious about all students learning rigorous and challenging mathematics, then we must get serious about the task of ensuring access to reasonable resources for all students, regardless of where they live.

We must question not whether to use technology, but how to use it in ways that support the mathematics learning of every student. If students do not learn appropriate ways to use technology in school, they will surely find inappropriate ways to use it outside of school. Our responsibility, then, is to ensure not only that do students have access to technological tools, but also that we take full advantage of these tools to help students learn the complex quantitative and thinking skills they will need as they enter our technology-driven workforce.

Reflection and Discussion

FOR TEACHERS

- What issues or challenges does this message raise for you? In what wa do you agree with or disagree with the main points of the message?
- What challenges do you face in using technology to support student learni
- How can you address the financial and equity issues related to providi all students with technology? How can you handle related managemer issues, like keeping equipment in working order and accounted for?
- In what ways do you effectively use technology to raise the level of mathematics your students learn?
- How do you support teachers in being selective and strategic about when students may use calculators and when they should not? How d you make such decisions?
- How can you learn about how to use emerging technologies that migh be useful and appropriate for students to raise their level of mathemat learning?

FOR FAMILIES

- What questions or issues does this message raise for you to discuss wit your son or daughter, the teacher, or school leaders?
- What mathematical skills did you learn in school that may no longer have the same importance? What mathematical topics are important today that you did not learn in school?
- What questions can you ask at school to learn more about when and how the teacher expects students to use calculators or computers both in school and outside of school?
- What can you do if you don't have the resources to provide your son c daughter with the kind of technology he or she might need? How can you find out what resources or assistance the school can provide?

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